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Optimally Clocking the Low Carbon Energy Mile to Achieve the Sustainable Development Goals: Evidence from Dundee's Electric Vehicle Strategy †

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† The present work is an extension of the paper "Can green infrastructure development in cities be equitable? An eclectic review of Dundee City's electric vehicles strategy" presented to the Second International Conference on Aligning Local Interventions with the UN Sustainable Development Goals (SDGs), 2 July 2020, Institute of Energy and Sustainable Development, De Montfort University, Leicester, UK.

Abstract: Dundee City has been successful in installing green infrastructure for charging electric vehicles (EVs). This intervention matches the Sustainable Development Goals (SDGs) of affordable clean energy (SDG 7), sustainable cities and communities (SDG 11) and climate action (SDG 13) of the United Nations General Assembly Agenda 2030 (Transforming our World: the 2030 Agenda for Sustainable Development). Local authorities can align interventions with SDGs according to needs. The purpose of this paper is to consider whether Dundee's EV strategy represents the most viable and equitable intervention that could be adopted given the city's context. We adopt a positive review and value argumentation approach to determine the extent to which the strategy satisfies the criteria of "level of urgency", "systemic impact" and "policy gaps", which have been employed in the extant literature as the basis for a multi-criteria analysis (MCA). We eclectically review elements of the strategy against the city's peculiar physical and socio-economic environment, as well as argue their fit against these criteria. We interpret these criteria based on the complementarity and benefits of the strategy from the lenses of SDG 7, SDG 11 and SDG 13. Additionally, we consider the alignment of the EV strategy with the other SDGs. The criteria also allow us to evaluate the strategy based on the localisation principles of equity, acceptability and affordability of the intervention. Our review shows that the EV strategy represents a sustainable and community life-enhancing intervention that aligns with some key SDGs. However, the outcome raises concerns about the equitability of the strategy. Smaller, similar or bigger cities could utilise this approach. However, we recommend the evaluation of local priorities to improve alignment with the SDGs and the provision of clear justifications for selecting an intervention from a range of responses.

Keywords: green infrastructure; electric vehicle; low carbon energy; localisation; equitability; viability; sustainable development goals; value argumentation; eclectic review

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1. Introduction and Background Literature

1.1. Introduction

Countries of the world agree to the Sustainable Development Goals (SDGs) outlined in the United Nations General Assembly Agenda 2030 [1]. However, understanding the mechanisms of national SDG implementation is crucial [2–4]. A lack of such understanding creates a two-fold problem. First, the high-level SDGs must translate into identifiable

interventions or actions that are contextually relevant to the needs of an adopting country. These responses could range from national priorities [5,6] to the specific developmental needs of local authorities, cities and communities, where some of the considerations highlight—and must necessarily prioritise—peculiar issues and challenges [7,8]. Second, SDG interventions may lack suitable indices to facilitate the proper linking of responses with the targets and indicators prescribed by the SDGs, or for comparison between countries [9–12].

The above problem makes it necessary to examine the alignment of local-level interventions with the SDGs, given that local authorities undertake a myriad of development interventions. Where the localisation of interventions precludes the exploitation of synergistic opportunities for cross-impacting other areas and challenges, outcomes will be suboptimal, as observed with the predecessor Millennium Development Goals (MDGs) [13,14]. Moreover, the decision-making process must address trade-offs in tackling the specific developmental needs of local authorities and communities. It must also recognise the benefits of joined-up thinking to deliver interlinked SDG interventions across autonomous units locally, nationally or more widely [15]. Cohen and Wiek [16] identify the misalignment between participation and local context as a reason for unequal distribution of benefits and detrimental prioritisation of private interests. This misalignment raises questions about the viability and equitability of the different ways for achieving the SDGs, given the variations in local conditions, constraints and opportunities. Even a rational decision-making approach for localisation of intervention may not be enough since, for example, in promoting energy transitions, non-linear dynamics and social, political and cultural issues come into play [17].

Since the inception of Agenda 2030 [1], the extant literature has severally reviewed the criteria for deciding on the SDG targets to prioritise through evaluative and analytical mechanisms built into the decision-making process. For instance, Allen, Metternicht and Wiedmann [18] argue that the SDG targets could be assessed and prioritised taking into consideration the "level of urgency" of the intervention, their potential "systemic impact" and the "policy gaps" to which they relate. The criteria used could range from scientific review of facts and formal knowledge to politically driven bargaining and value assessment arising from power relations [19]. Given the numerous and sometimes diametrically opposed nature of available criteria—e.g., where a low-cost intervention may lack broad social acceptance—prioritising interventions to optimise the SDG outcomes is a challenge for local authorities.

Furthermore, having selected and implemented an intervention, a process for reviewing and assessing the progress made towards achieving the SDGs is vital. Thus, the UN Agenda 2030 [1] encourages voluntary reviews aimed at facilitating the exchange of experiences—including success, challenges and lessons learned. Since initial interventions from the adoption of the SDGs are now beginning to yield observable outcomes, it is pertinent to start evaluating how well such interventions are contributing to achieving the SDGs. This research will undoubtedly complement previous studies which focused on the intervention selection or prioritisation process. Post-implementation reviews to appraise the effectiveness of interventions while offering feedback for improving future decision-making about interventions are required. Our review of Dundee's electric vehicle (EV) strategy falls into this category.

1.2. Context and Purpose of the Research

In "Dundee's green revolution" [20], the Dundee City Council (DCC) embarked on an ambitious plan of installation of regular and solar-powered charging points for EVs and commissioned several electric bin lorries. The city was named Europe's most visionary EV city by the World Electric Vehicle Association (WEVA) at a ceremony in Kobe, Japan in 2018. DCC's approach represents an intervention which appears to fit with the SDGs of affordable clean energy (SDG 7), sustainable cities and communities (SDG 11) and climate action (SDG

13). Its acclaim suggests that this intervention—aimed at a low carbon outcome—has been a remarkable success.

However, it is pertinent to evaluate whether the low-carbon benefits of the intervention to Dundee are commensurate with the media commendation of the intervention [21]. Accordingly, the purpose of this paper is to consider whether Dundee's EV strategy represents the most viable and equitable intervention that could be adopted given the city's context. An ex post facto review of this intervention in Dundee is useful for examining whether the intervention can be justified in retrospect while yielding valuable lessons for similar interventions or for stakeholders that have the task of selecting interventions for SDG purposes.

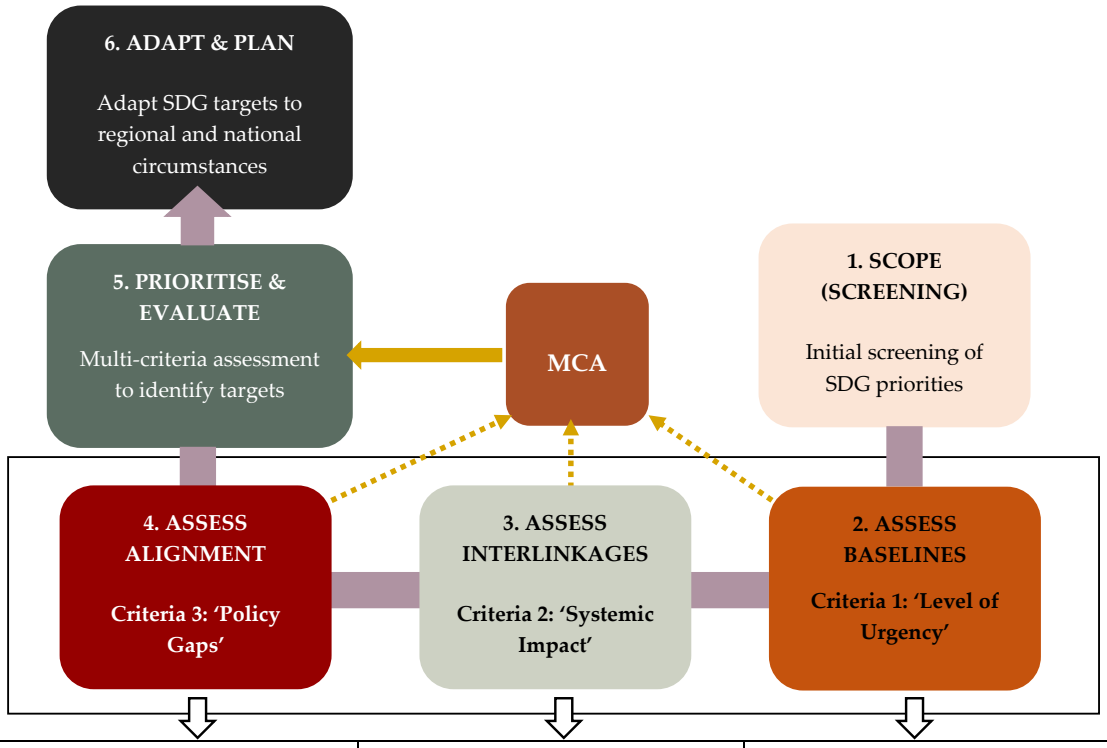
In the context of the city's peculiar physical and socio-economic environment, we examine the viability and reasonability of the EV intervention using key evaluation criteria of "level of urgency", "systemic impact" and "policy gaps", as enumerated in the methodology section below. The extent to which the EV strategy of the DCC represents an equitable approach for the city's residents and stakeholders could be inferred from the complementarity and benefits of the plan from the apparent lenses of SDGs 7, 11 and 13. It can also be understood from the alignment of the EV strategy with the other SDGs. In addition, the approach is evaluated relative to other interventions that could offer similar and arguably better prospects for sustainable living in a low-carbon energy community. Thus, we review the elements of the plan and the city's peculiar physical and socio-economic environment for the uptake of EVs. We question whether the perceived benefits fully match the SDGs based on the localisation principles of equity, acceptability and affordability by residents of the community. Our objective in this review is to understand Dundee's approach from the expressed or implied justifications of the EV intervention. Additionally, we consider the prospects of its scalability and adoption by smaller, similar or more prominent cities in a way that optimises the potential for low-carbon development by extracting useful lessons from the intervention.

2. Methodology

Kim [22] employs a positive review and value argumentation method to explain Korean and Taiwanese policymakers' strategic view of smart microgrids as a new developmental infrastructure for making their domestic firms competitive via hybridised industrial ecosystems which bring together innovation champions. Hammitt [23] submits that positive and normative justifications may conflict when undertaking benefit–cost analysis, i.e., people's apparent preferences may differ from what is normatively acceptable. Similarly, our positive review and value argumentation approach involves considering the extent to which Dundee's EV strategy satisfies the criteria of "level of urgency", "systemic impact" and "policy gaps". These criteria were propositioned by [18]. An eclectic positive review of elements of the strategy against the city's peculiar physical and socio-economic environment is undertaken, and normative or value arguments are offered to appraise their fit with these evaluation criteria. By examining this specific programme of intervention in a grassroots setting, we engage with the above considerations to contribute to the body of evidence and to extract useful decision parameters for evaluation and selection of SDG-related interventions.

Allen et al.'s multi-criteria analysis (MCA) [18] is a sequence of steps (top half (chart) of Figure 1): step one, consultatively screening a broad set of SDG targets and indicators to prioritise for a region; step two, quantitively assessing trends and progress towards establishing the "level of urgency" of each target/indicator; step three, undertaking systems analysis of interlinkages among the SDG targets to assess the "systemic impact" of each target and identify high-leverage targets; step four, qualitatively assessing the alignment of the SDG targets with existing regional and national strategies to establish "policy gaps"; step five, further consultatively discussing and validating the outcomes of scoring and weighting the SDG targets using the criteria in steps two to four; which culminate in

step six, adapting SDG targets to regional and national circumstances to allow for an implementation framework with proposed SDG target values.



Assess alignment of the SDGs with existing strategies and plans	Assess interlinkages between SDG targets and identify high-leverage targets	Baseline assessment of SDG indicators—trends and benchmarking of progress
Positive review and value argumentation parameters		
	Dundee city and its contextual settings (Section 3)	
The Policy Framework informing Dundee's EV strategy (Section 4)		
Analysing the equitability and viability of Dundee's EV charging infrastructure (Section 5)		
Linkage of Dundee's intervention measures to SDGs (Section 5.1)		
Dundee's EV charging infrastructure development (Section 5.2)		
	Equitability of location of infrastructure, deprivation index and access (Section 5.2.1) Affordability: funding arrangements and incentivisation (Section 5.2.2) Planning authority considerations (Section 5.2.3)	
User penetration and cross-county/national opportunities (Section 5.2.4)		
Acceptability relative to alternative or complementary low carbon schemes (Section 5.2.5)		
Summary of evaluation points		
Devolution and local priorities; mapping to National Performance Framework and DCC actions; as well as alignment with SDGs.	Incentives for EV adoption; interconnectivity with other local authorities; and alignment with SDGs.	Location of infrastructure, deprivation index and accessibility; acceptability, affordability.
Nature of arguments		
Qualitative	Quantitative, qualitative (mixed)	Quantitative, qualitative (mixed)

Figure 1. Positive review and value argumentation parameters linked to Sustainable Development Goal (SDG) prioritisation criteria. Top half: the multi-criteria analysis (MCA) of [18] (pp. 423–424); bottom half: adaptation of MCA for the positive review and value argumentation of Dundee's electric vehicle (EV) strategy through evaluation against the MCA criteria: "level of urgency", "systemic impact" and "policy gaps".

The MCA framework [18] was employed in the Arab national and regional context, with targets and indicators based on data produced either frequently or using a clear method under the guidelines of the UN Statistical Commission. The level of consultation and granularity of measurement of targets and indicators at local authority level may be inhibited by lack of sufficient trends for quantitative assessment of the targets and indicators implied in the framework. The framework represents a rigorous review of the SDG targets and indicators for setting SDG priorities. However, it is only intended for supporting the initial stages of implementation of the SDGs. Post-implementation, the voluntary national reviews—which facilitate the sharing of experiences [1]—are undertaken at the national and regional levels, with the comparability of data a potential issue. Breuer et al. [7] describe these issues as representing three methodological challenges of first, conceptually translating the SDG targets into measurable indicators; second, operationalising the securing of data to empirically assess interlinkages between goals; and third, establishing and replicating—i.e., reproducing and verifying—the processes used to estimate the nature, strength and relevance of interlinkages between the SDGs.

We use the implementation of the Dundee EV strategy as an SDG-linked intervention case study to perform a retrospective evaluation of the intervention's alignment with the SDGs in general terms rather than as a system for coding or weighting granular targets and indicators for selection of an intervention. Accordingly, we adopt and holistically review the criteria ("level of urgency", "systemic impact" and "policy gaps") included in the MCA framework steps two to three [18] from a positive review and value argumentation of the context-sensitive and observable features of the intervention. Context sensitivity and issues with replicability remain key inadequacies of existing SDG implementation frameworks and mapping approaches [7], and local authorities may not provide or consistently report granular SDG targets and measures due to lack of capacity or funding or the absence of demand for such information. For example, Dundee's Climate Action Plan (CAP) [24] provides top-level linkages to the seventeen SDGs through sixty-four actions, which encompass but are not specifically individually linked in the document to the SDGs' 169 targets and 230 indicators.

Our adoption of the MCA framework [18] to perform a positive review and value argumentation is depicted in the bottom half—from the table row labelled "Positive review and value argumentation parameters"—of Figure 1, where the parameters are referenced to numbered sections of this paper. The "level of urgency", "systemic impact" and "policy gaps" criteria are used as argumentation parameters to eclectically review the different aspects of Dundee's EV intervention. Thus, we assess the "level of urgency" and "systemic impact" from the location of Dundee's settlements relative to the situation of charging infrastructure. This involves examining the local context of Dundee as an enabler of or impediment to the kinds of SDG interventions being pursued by the DCC (Section 3). These contextual issues can promote equitability or exacerbate inequalities. Similarly, we consider the "policy gap" and "systemic impact" from the relationship or linkages of Dundee's intervention to the eleven national outcomes of the Scottish National Performance Framework (NPF) [25,26] via the SDGs, especially since in the United Kingdom (UK) government, devolution means that national and local governments can select priority areas to focus on. We review the policy framework cascading from the country/national to local authority levels for Dundee's EV strategy (Section 4).

Furthermore, we combine these two strands of arguments to assess the factors that have led to the emergence of Dundee as an EV charging infrastructure champion and determine the equitability and viability of the strategy (Section 5). These encompass the three criteria of "level of urgency", "systemic impact" and "policy gaps" (the bottom half (table) of Figure 1 depicts how these criteria fit with the subsections of our discussion). We undertake a high-level mapping approach for examining the links between national and local action plans and the SDGs (Section 5.1). Thus, we interpret the "policy gaps" and "systemic impact" criteria from the standpoint of the complementarity and benefits of the Dundee EV strategy from the lenses of SDG 7, SDG 11 and SDG 13, as well as the

alignment of the EV strategy with the other SDGs and the NPF. We consider all three criteria in reviewing the development of Dundee's EV infrastructure (Section 5.2) to allow us to evaluate the strategy based on the localisation principles of equity, acceptability and affordability of the intervention. This includes evaluating the location of the infrastructure relative to areas of deprivation, affordability (including funding arrangements for the EV strategy and overall financial commitments to activities and objectives allied to the other SDGs), planning authority considerations, user penetration and cross-country/national opportunities, and a review of alternative low-carbon interventions.

The discourse evaluates the stated and implied benefits of the EV strategy by appraising issues around the location of EV infrastructure, access and incentive schemes in line with the Energy Savings Trust guidelines for EV infrastructure development [27,28]. We appraise the equitability and viability of the intervention using the preceding strands of the arguments—which involve qualitative and quantitative attributes (Figure 1)—to make critical recommendations and conclude the study (Section 6). Whereas the EV strategy represents a sustainable and community life-enhancing intervention that aligns with some SDGs, there are concerns about the equitability of the strategy. The implication is that local priorities should be evaluated to improve alignment with the SDGs and clear justifications provided for selecting an intervention from possible responses.

3. Dundee City and Its Contextual Settings for Prioritisation of the EV Intervention

Dundee is Scotland's fourth-largest settlement after Glasgow, Edinburgh and Aberdeen, with a mid-2020 population estimate of 148,577 and population density of 2478 per square kilometre [29]. It is on the north bank of the Firth of Tay (latitude 56.462° North, longitude 2.9707° West), an historically significant North Sea trading coastal station that attained city status in 1889 [30]. Its location means that the city experiences a lot of sunny days with reasonable day and night temperatures and precipitation throughout the year—Figure 2 provides average monthly values for these meteorological factors during 2015–2020. Dundee gained prominence in the Industrial Revolution and has witnessed many "transitions", with the emergence and/or waning of industries and activities in cotton processing and textile trading, jute milling, jam processing, journalism, shipbuilding and whaling [30,31]. Constant transformation, a reputable record of scientific discoveries and contributions to comics, video games and medical research have earned Dundee recognition as the UK's first UNESCO City of Design [32].

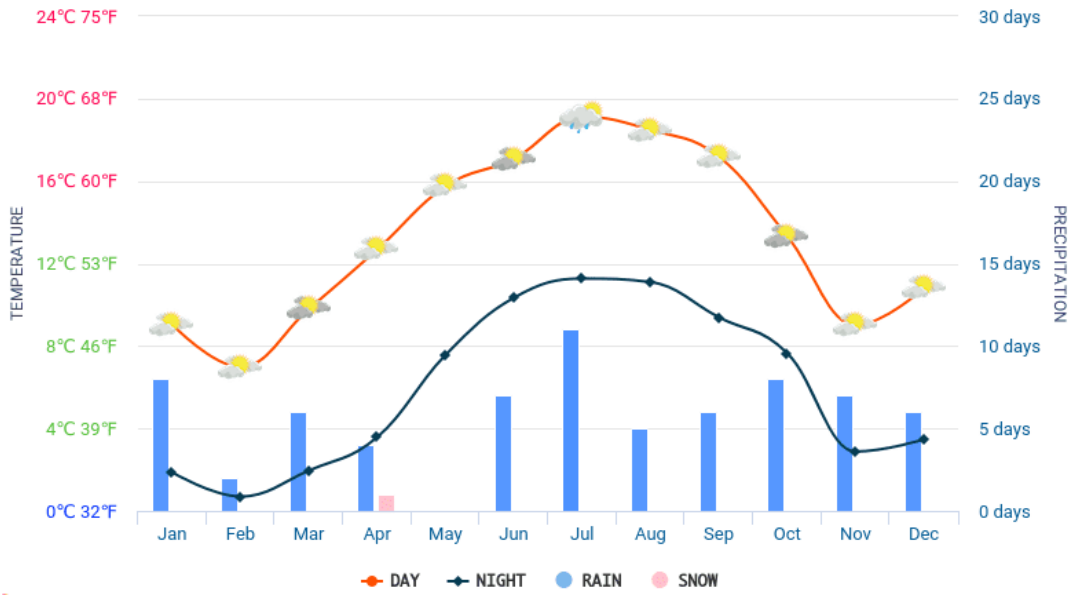


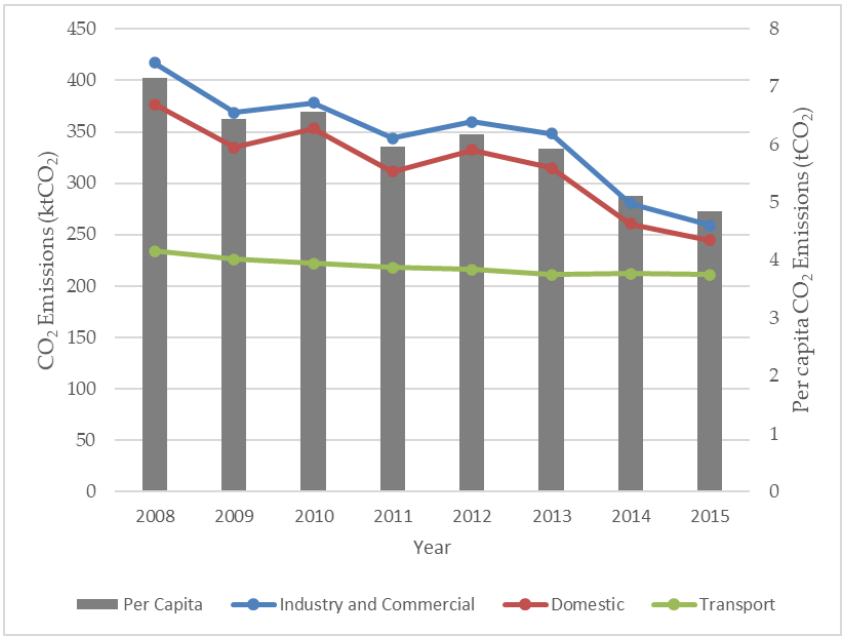
Figure 2. Dundee, Scotland weather (average monthly temperature and precipitation (rain and snow), and sunny and cloudy Days, 2015–2020) (source: hikersbay.com/climate/scotland/dundee (accessed: 25 September 2020)).

Dundee's historical development and links to an industrial past influence its developmental outlook. For instance, its ancient housing development plan had involved the development of low-cost housing estates to provide accommodation for the young workforce—likely to be upwardly mobile working-class population sensitive to environmental impact—servicing its numerous industries. With over 80% of Scotland's population also within 2-hour drive time of Dundee city [33], this creates a distinction between "home" and "destinations" (work locations, car parks, supermarkets, etc.) which favour a hub approach to EV infrastructure selection and development [27]. It also makes the existence of allied or related industries and skills that can be transitioned more likely [34]. Developmental plans for such areas often include addressing infrastructural deficits through a complete upgrade or costly refurbishment that pose both planning and technical challenges for EV infrastructure location [28,35]. With an environmentally aware population—Friends of the Earth Tayside lists over 40 entities (voluntary organisations and initiatives, green businesses and political parties) in its 2018 directory of green groups—and City Council leadership that are championing a green ecosystem development, Dundee may be justifiably pursuing an EV infrastructure agenda. Dundee City Council is currently led by John Alexander (SNP) who became Dundee's youngest ever serving councillor at 23 years old when elected in 2012. The Council has been adopting green policies, including declaration of a climate emergency in 2019. However, the policy framework that shapes the nature of participation of different stakeholders in interventions may mean that benefits are inequitably distributed [16].

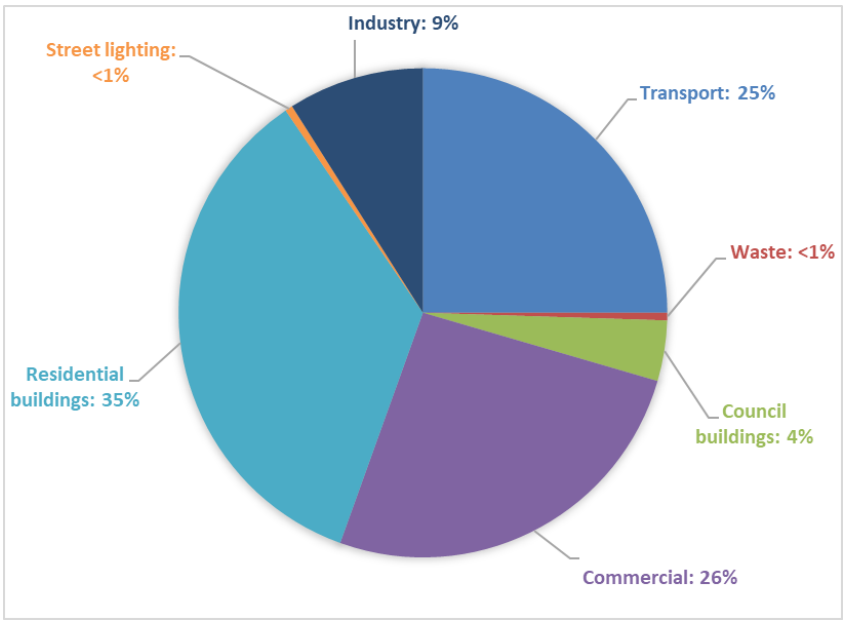
Part (a) of Figure 3 shows per capita CO_2 emissions (tCO_2) and CO_2 emissions ($ktCO_2$) by industry and commercial, domestic and transport sectors from 2008 to 2015; part (b) shows the percentage emission by all sectors in 2015. Part (a) indicates that reductions in CO_2 emissions have been mainly driven by reductions in industry/commercial and domestic sectors, which more closely mirror the per capita reduction in CO_2 emissions. Reductions in transport-related CO_2 emissions have been modest, with little movement between 2013 and 2015.

Figure 4 shows Dundee's top 5% most deprived areas based on the Scottish Index of Multiple Deprivation (SIMD) [36]. The index considers factors such as an area's income, employment, crime and health deprivation and disability. The map is superimposed with the location of Dundee's EV charging facilities. It appears that current charge points are not precisely situated within or around the most deprived areas. Choice of location for charge points considers complex factors like the type of technology and proximity of charge points to users and power source. The UK Office for Low Emission Vehicles (OLEV) recognises that this represents a barrier to EV ownership because it creates a two-tier system that disadvantages homeowners with no driveways [35].

The foregoing elements of Dundee's physical and socio-economic context are pertinent for determining the "level of urgency" and potential "systemic impact" of any development intervention. We explore areas requiring specific interventions for emissions reduction in relation to Dundee's EV strategy in Section 5.



(a)



(b)

Figure 3. Dundee carbon emissions: (**a**) three main sectors (industry and commercial, domestic and transport) and per capita (2008–2015) and (**b**) all sectors (2015) (sources: based on data from the Dundee Climate Action Plan [24] and data published by Sustainable Scotland Network https://sustainablescotlandnetwork.org/reports/dundee-city-council (accessed: 25 September 2020)).

Figure 4. Dundee's 5% multiple deprivation (red shaded) areas and location (icons) of EV infrastructure (sources: Scottish Index of Multiple Deprivation (SIMD), Google Map, Zap-Map (maps superimposed using Google Earth Pro)).

4. The Policy Framework Informing Dundee's EV Strategy

DCC EV strategy derives from the UK Agenda 2030 Global Goals [37]. The data required for tracking its implementation and performance on the United Nation's global indicators come from the National Reporting Platform of the Office of National Statistics (ONS), and other government and non-government sources. However, national governments can adapt their approach to devolved issues and how they use available data/definitions for implementing and reviewing the SDGs. Consequently, country and national priorities and developmental objectives in the UK have diverged [38,39]).

For local policy contextualisation, the Scottish Government has provided a National Performance Framework (NPF) with eleven national outcomes [25,26]. The Scottish Government works in partnership with the SDG Network Scotland (an open coalition of over 300 people and organisations across Scotland) and the Convention of Scottish Local Authorities (COSLA) to help local authorities (councils and communities, in this case, Dundee) to localise the SDGs according to the perceived needs of each area. Dundee has initiated SDG-related development plans through three vital documents—the City Plan 2017–2026 [40], the Council Plan 2017–2022 [41] and the Climate Action Plan (CAP) 2019 [24]. Each of these is subject to an annual review process. Dundee has in its climate emergency declaration pledged to embark on three fundamental actions under each of the SDGs [42]. CAP [24] provides a road map for a just transition to a net-zero and climate-resilient future, with targets set for 2045 and aligns with the Dundee waterfront development plan and the city's broader regeneration agenda.

As one of Scotland's thirty-two local authorities, planning guidance comes from the Scottish Planning Policy (SPP) [43]. The policy promotes the provision of infrastructure necessary to support positive changes in transport technologies, such as charging points for electric vehicles (section 275 of SPP) and requires that EV charge points be considered as part of any new development and provided where appropriate (section 289 of SPP). Consistent with the framework of Figure 5, the Climate Change Act 2008 (as amended in 2019) [44] legally binds the UK to achieve a 100% reduction in greenhouse gas emissions by 2050—from a 1990 baseline—and specific legislation and powers are vested on cities

and local authorities. Hanley [45] observes that local authorities can mandate a minimum percentage of parking spaces to be fitted with charging points in new developments and provide parking incentives for (ultra)low carbon vehicle ((U)LCV) users. They can also implement (U)LCV highway and access measures, including issuing a traffic regulation order (TRO) to create a (U)LCV lane, introducing a low emission zone or congestion charging. Local authorities can set up (U)LCV-related social enterprises or reduce business rates and consider whole-life environmental impacts when procuring or leasing road transport vehicles.

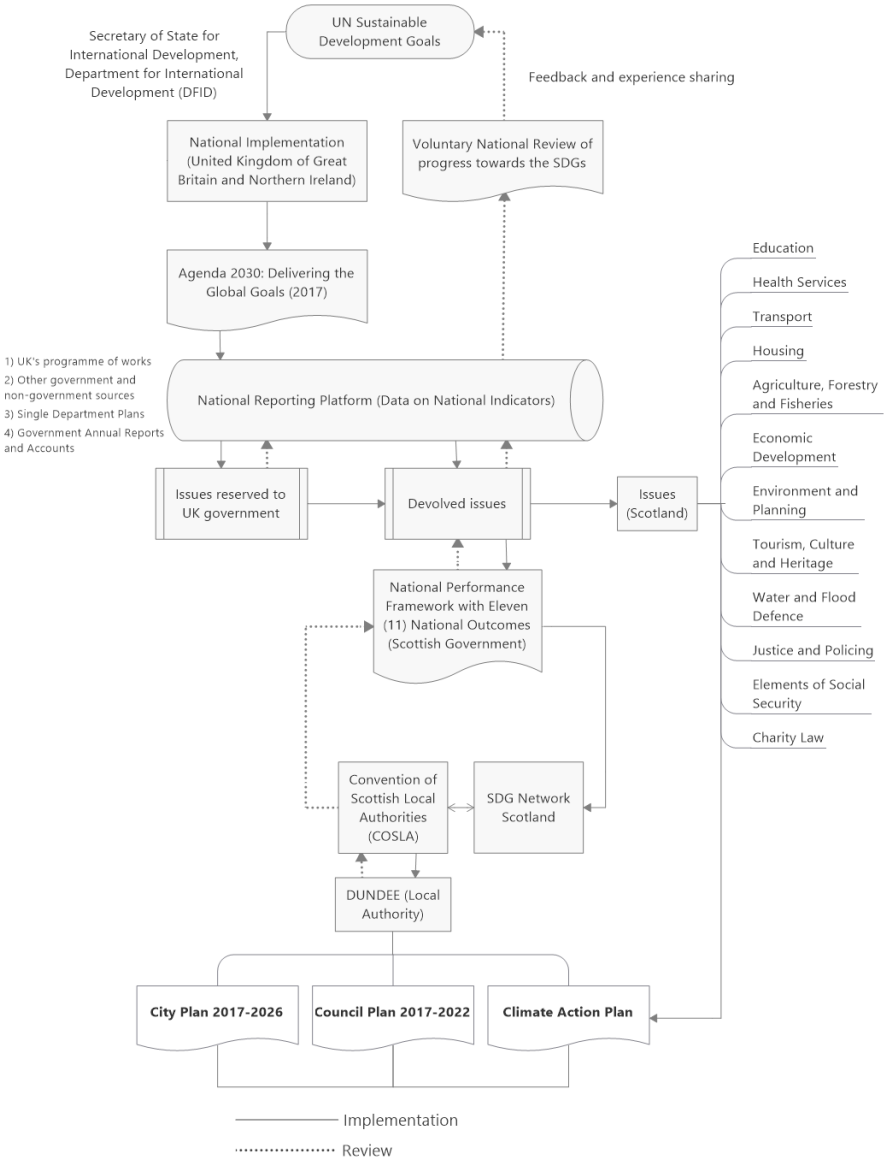


Figure 5. Model of SDG adoption (source: authors' review of Dundee's planning framework in the context of national planning arrangements).

The framework of Figure 5 assesses "policy gaps" in a context-specific way because of the devolution arrangement, which could see national governments and local authorities set their development priorities and agendas within the country-defined scope but with the flexibility to vary these to local circumstances. Similarly, the "systemic impact" of policies adopted and linked to the SDGs can be fully realised only to the extent that policies relating to UK government reserved issues clearly filter through to devolved national and local authority issues. These considerations are explored further in Section 5.

5. Analysing the Equitability and Viability of Dundee's EV Charging Infrastructure

5.1. Linkage of Dundee's Intervention Meaures to the SDGs

The City Plan [40] identifies five strategic priorities for which measurable outcomes have been specified: Fair Work and Enterprise (associated with three measurable outcomes); Children and Families (five measurable outcomes); Health, Care and Wellbeing (three measurable outcomes); Community Safety and Justice (six measurable outcomes); and Building Stronger Communities (five measurable outcomes). These are supported by strategic service areas in the Council Plan [41] with service area scorecards for Children and Families; City Development; Dundee Health and Social Care Partnership; Neighbourhood Services; Leisure and Culture; Corporate Services; and Chief Executive's Services. Sitting alongside these plans is the CAP [24] (pp. 59–67) which specified the DCC's interventions as sixty-four different actions. These sixty-four actions are grouped into five action themes: "general" (consisting of six actions), "energy" (eighteen actions), "transport" (ten actions), "waste" (nine actions) and "resilience" (twenty-one actions). The six actions in the general category were not mapped to the SDGs. However, each of the remaining fifty-eight actions (relating to the energy, transport, waste, and resilience themes) is linked by the DCC to one or more SDGs. We provide our mapping of these linkages in Figure 6. In Figure 6, each bar represents the number of times different actions are linked to each of the SDGs. Thus, SDG 1 (no poverty) is linked to six actions (five relate to energy and one relates to resilience), SDG 2 (zero hunger) is linked to a single resilience action, SDG 3 (good health and well-being) is linked to nineteen actions (ten relate to transport, eight to resilience and one to waste), etc.

The numbers at the base of each composite bar in Figure 6 represent the ranking of the SDGs by the frequencies with which DCC actions are linked to the SDGs. Thus, SDG 13 (climate action), SDG 11 (sustainable cities and communities) and SDG 12 (responsible consumption and production) are the top three SDGs linked to DCC's actions. Surprisingly, SDG 7, which was expected to have an obvious link with Dundee's intervention is only ranked seventh, with fifteen (fourteen energy and one resilience) actions linked to it. However, when only the energy-themed actions are considered, the top three SDGs are SDGs 13, 11 and 7, with eighteen, sixteen and fourteen energy-themed actions, respectively. SDG 2 (zero hunger), SDG 4 (quality education) and SDG 5 (gender equality) are the least ranked, with only one action theme—resilience—and precisely one action linked to each. SDG 6 (clean water and sanitation), SDG 14 (life below water) and SDG 16 (peace, justice and strong institutions) are also linked to only the resilience theme but are linked to five, seven and two actions under this theme, respectively. By counting the number of SDGs linked to actions within each theme, Figure 6 also reveals at least one energy-themed action is linked to nine of the SDGs. Similarly, transport-, waste- and resilience-themed actions are linked to seven, eight and sixteen unique SDGs, respectively.

Employing network analysis [46,47], we produce a mapping of the eleven national outcomes of the Scottish NPF [25] with the SDGs to which each outcome has been associated. On the left-hand side of Figure 7, the bracketed number for each national outcome is the number of linked SDGs, with a line drawn to connect the relevant SDG in the middle of Figure 7. We include, on the right-hand side of Figure 7, lines linking the CAP [24] action themes to their associated SDGs. Thus, on the right-hand side of Figure 7, the DCC action themes are specified as theme (n, m), where n is the number of individual actions specified by DCC for a theme and m is the number of unique SDGs linked to the theme. Accordingly, Energy (18, 9) implies there are eighteen energy-themed actions linked to nine distinct SDGs (i.e., from the previous analysis in Figure 6); the nine lines from this cell link the theme to the nine relevant SDGs. In the middle of Figure 7, the SDGs are specified as (x) N (y), where N is the SDG number, x is the number of national outcomes linked to the SDG from the left and y is the number of DCC action themes linked to the SDGs from the right. Thus, (3) 1 (2) implies three national outcomes and two DCC action themes are linked to SDG 1 (no poverty).

SDG 13, SDG 14 and SDG 15 are linked to exactly one national outcome each. Similarly, SDG 2, SDG 4, SDG 5, SDG 6, SDG 14 and SDG 16 are linked to exactly one Dundee climate action theme each. There are ten SDGs (SDG 1, SDG 2, SDG 4, SDG 5, SDG 6, SDG 7, SDG 9, SDG 10, SDG 12 and SDG 16) for which linked national outcomes are more than linked Dundee action themes (i.e., where x > y using the (x) N (y) notation), there are four SDGs (SDG 11, SDG 13, SDG 15 and SDG 17) for which linked DCC actions are more than linked national outcomes (i.e., y > x), with a tie (i.e., x = y) in SDG 3, SDG 8 and SDG 14. The SDGs most frequently linked to national outcomes are SDG 5 (all eleven national outcomes), SDG 10 (ten national outcomes) and SDG 7, SDG 9 and SDG 12 (five national outcomes each). Gender equality (SDG 5) seems to feature prominently in the national outcomes but is only matched to one of Dundee's action themes. All four Dundee action themes of energy, transport, waste, and resilience were linked to SDG 9, SDG 11, SDG 13 and SDG 17.

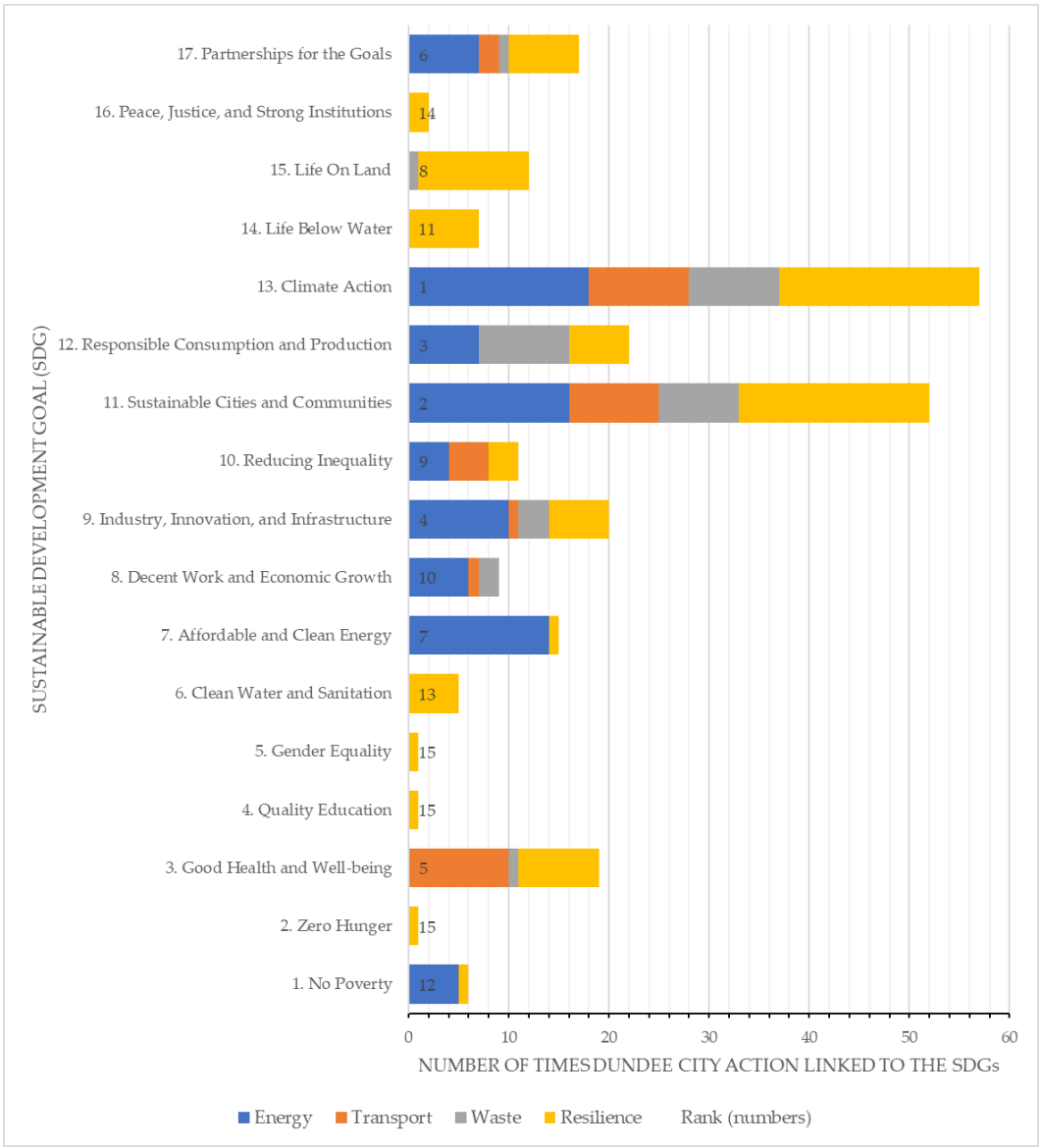


Figure 6. Frequency of linkage of Dundee's energy-, transport-, waste- and resilience-themed actions to the SDGs (source: authors' analysis of Dundee's identified actions in the Dundee Climate Action Plan [24]).

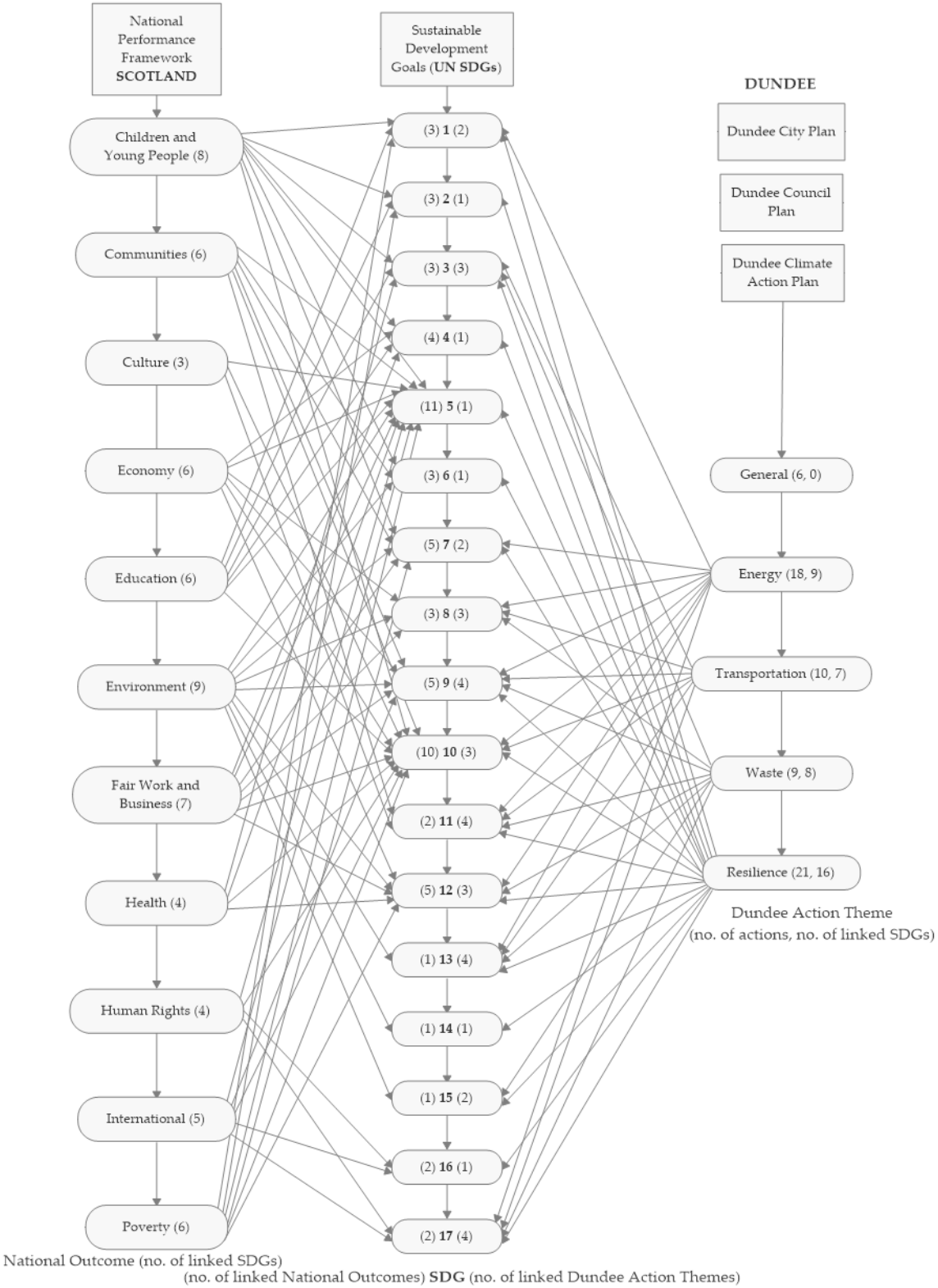


Figure 7. Scottish National Performance Framework (NPF) [25] outcomes and Dundee's action themes mapped against the SDGs (source: authors' mapping of Dundee City's plans through the four Dundee Climate Action Plan (CAP) [24] themes of energy, transport, waste and resilience and the Scottish NPF [25] outcomes to the SDGs).

The differences between the frequency of linkage of the national outcomes and DCC's action themes to the SDGs may suggest that the SDGs provide a means for linking interventions at the local authority level (Dundee actions) to outcomes at the national level

(Scottish NPF outcomes). The divergence of country and national priorities and developmental objectives in the UK [38,39] continues to the local authority level. However, if the SDGs are accepted as the ultimate goal to be achieved, then it should mean that "policy gaps" between national level and local interventions will be minimised so long as each has been selected or specified to achieve the indicated SDG. In line with the devolution arrangement and model of SDG adoption presented in Figure 5, local authorities have and do exercise the power to pursue interventions based on their local needs and priorities—"level of urgency". It should not matter that the number of national outcomes linked to the SDGs differs from the number of Dundee actions linked to the SDGs so long as the local authority is prioritising interventions that specifically link to the SDGs. The number of links established between national outcome and SDGs, as well as between Dundee action and SDGs is not necessarily an indication of the strength of the linkage. However, the existence of a link to all seventeen SDGs should assure that enough actions have been specified for "systemic impact" in relation to the indivisibility of the SDGs and the need to implement them in an integrated manner [1]. Thus, a single link to an SDG could be as significant as multiple links since the single link suffices to indicate an action or national outcome is achieving a given SDG. In this case, multiple links from an action to an SDG will represent different aspects or measures of the adopted intervention. Moreover, it may also be that some of the goals are indirectly linked to the stated interventions so that while an action is linked to SDG 1 (no poverty), for instance, it may mean that it indirectly helps to attain, for example, SDG 2 (zero hunger).

Finally, combining Figures 6 and 7, we interpret these results as meaning that Dundee's intervention has been selected purely with a consideration of the local "level of urgency" in mind. It means that the intervention need not match the same SDGs as the national outcomes but the SDGs that are relevant to the needs of the local authority. This is consistent with the ethos of allowing local authorities to identify and pursue interventions that are more relevant to local needs. The activities identified by Dundee relate specifically to [24]. These actions have been specified to achieve high-level alignment with the SDG. Linking the national outcomes to SDGs means that local authorities are assured—through alignment with the SDGs—their interventions are indirectly aligning with the national outcomes. Low-level mapping of the SDG targets and indicators will be required to match specific national outcomes to Dundee's actions. For instance, the twenty-one resilience-themed Dundee actions link to sixteen of the seventeen SDGs; this will represent a broad range of targets and indicators given that 169 targets and 230 indicators are specified for the SDGs [1].

5.2. Dundee's EV Charging Infrastructure Development

The preceding linkage evaluation process uses Dundee's stated connection between the actions specified in [24] and the SDGs. EV charging infrastructure is explicitly mentioned concerning SDGs 11 and 13 in Dundee's climate emergency declaration [42]. The CAP [24] directly articulates "transport" actions—transport became the largest emitting sector of greenhouse gas (GHG) emissions in 2016 and accounts for 31% of emissions in the 2018 national statistics [48]—and provides implied actions relating to "energy", particularly the installation of photovoltaic panels which are used to power some of the EV charging hubs. These are allied to the objectives of clean, efficient and low-carbon energy (SDG 7). In the final part of our analysis, we review the operational aspects of the infrastructure provisioning to comment on their linkages to the SDGs given the foregoing contextual issues of the selected case. We review the overall equitability, acceptability, acceptability and affordability of the scheme as a low-carbon pathway when these localisation principles are considered within the criteria of "level of urgency", "systemic impact" and "policy gaps".

5.2.1. Equitability of Location of Infrastructure, Deprivation Index and Access

Charging infrastructure could be classified as Standard or "slow", Fast or "destination" and Rapid or "en route" charge points. Slow chargers are typically rated 3.7–7 kW AC

for at home, off-street or lamppost overnight or top-up charging. Fast chargers are rated 7–22 kW AC for daytime, "grazing", top-up or overnight charging for on-street, car park, supermarket or workplace charging. Rapid chargers are rated 50+ kW DC/43 kW AC intended for motorways and A roads, petrol stations and busy roads with a time to 80% or full charge of 20-40 minutes for on-the-go use. In the map of Figure 4, the Scottish Index of Multiple Deprivation [36] could be indicative of areas where access to on-street parking could be an issue. However, fast and rapid type charging infrastructure predominates in Dundee at specific destinations: work, and car park and hub (including taxi charging), locations (Table 1). The previous contextual review (Section 3) favours commuters or "destination" charging users [49] that can access Dundee's location for work or leisure from across the country. This appears to align with SDG 8 (decent work and economic growth) but brings equitability of infrastructure into doubt for domestic users who do not require charging, contrary to SDG 10 (reducing inequality). The "level of urgency" of the intervention is not driven by the need to address things like poverty and deprivation, but to satisfy broader climate change objectives—which could address deprivation through "systemic impact" on the city's economy. Additionally, the infrastructure indirectly links with SDG 4 in being situated in schools and universities in Dundee, together with the uptake of research into sustainability issues—offering opportunities to meet other targets through the "systemic impact" created.

Table 1. List of charge points in Dundee categorised by location and type.

		Location							
Type	**Rating/Connector**	**Car Park**	**Hub**	**On Street**	**Supermarket**	**Taxi Hub**	**Workplace**	**Total**	**%**
Slow	3 kW 13A 3-Square pin						1	1	0.8%
Fast	7 kW 32A Type 2 Mennekes	18		10	4		7	39	48.4%
	22 kW 32A Type 2 Mennekes		14	4			3	21	
Rapid	43 kW 63A Type 2 Mennekes	2	12	2		5	1	22	50.8%
	50 kW 125A CCS (Combo)	1	12			5	2	20	
	50 kW 125A JEVS (CHAdeMO)	2	12			5	2	21	
Total		23	50	16	4	15	16	124	

Data source: Zap-Map (available online: https://www.zap-map.com/locations/dundee-charging-points/ (accessed: 22 May 2020)).

5.2.2. Affordability: Funding Arrangements and Incentivisation

Green infrastructure has been associated with above-average payback periods and modest return on investment—at least in the early stage—because of high upfront costs, uncertain or disjointed policy environment and market failures [50]. Where immediate payback or payoff is unlikely, there must be other sound bases for justifying investment in green infrastructure and for determining viable ways for achieving uptake of the use of clean, efficient and low-carbon energy and applications. Increasingly, alignment with the SDGs can provide a veritable framework for green infrastructure project selection and execution [51]. Typically, the arguments have centred on promoting care for the environment and reduction of GHG emissions and global warming. Grant funding by the Office for Low Emission Vehicles (OLEV) supports home charging and workplace charging schemes. In addition to these, Transport Scotland also provides grants and support in the form of Switched on Towns and Cities Feasibility Studies; the Switched on Towns and Cities Challenge Fund; ChargePlace Scotland (funding public charge points at destinations

and for workplaces to install EV charging infrastructure); and the Low Carbon Transport Loan Fund [27].

With the growing demand for charge points and reducing unit cost, the use of concessionary contracts to build and operate charge points for a profit have become popular. Concessionaires take advantage of localised demand conditions—e.g., private land access and the growing popularity of EV cars—and supply factors—e.g., using wind and solar PV technology—to overcome limitations previously constituting an entry barrier. The conditions in Dundee as described in Section 3—climatic conditions and CO_2 emissions levels—will suggest good uptake of the opportunity to build charging infrastructure. Given that the highest reductions in CO_2 emissions during 2008–2015—Figure 3a—have been in industrial/commercial and domestic sectors, there may be a strong case for the prioritisation—i.e., a high "level of urgency"—of the EV strategy as a way of ensuring that transport-related emissions also start to decline at the rates observed for industrial/commercial and domestic sectors. Conversely, with industrial/commercial and domestic emissions still higher than transport emissions, the argument arises that the most significant possibility for achieving overall—"systemic impact"—reductions in CO_2 will be by focusing on industrial/domestic and domestic interventions.

Dundee has been successful in securing various grants and funding for its EV charging infrastructure development. It was awarded GBP 515,500 for the installation of 11 Rapid and two Fast charge points in the first round of funding in the ultra-low emission vehicle (ULEV) Taxi Infrastructure Scheme. The Energy Saving Trust (EST) [52] also indicates that Dundee has received GBP 576,774; GBP 692,540 and GBP 126,231 under the Business, Domestic and "Switched on Taxi" (SOT) Low Carbon Transport Loan scheme since the 2011/12 financial year. The funding paid per financial year in Scotland by loan type—business, domestic, hackney and SOT (launched in 2019) and in total—since inception are shown in Figure 8. The various funding schemes could help local authorities afford the cost of EV infrastructure, ensuring that much more "systemic impact" can be achieved.

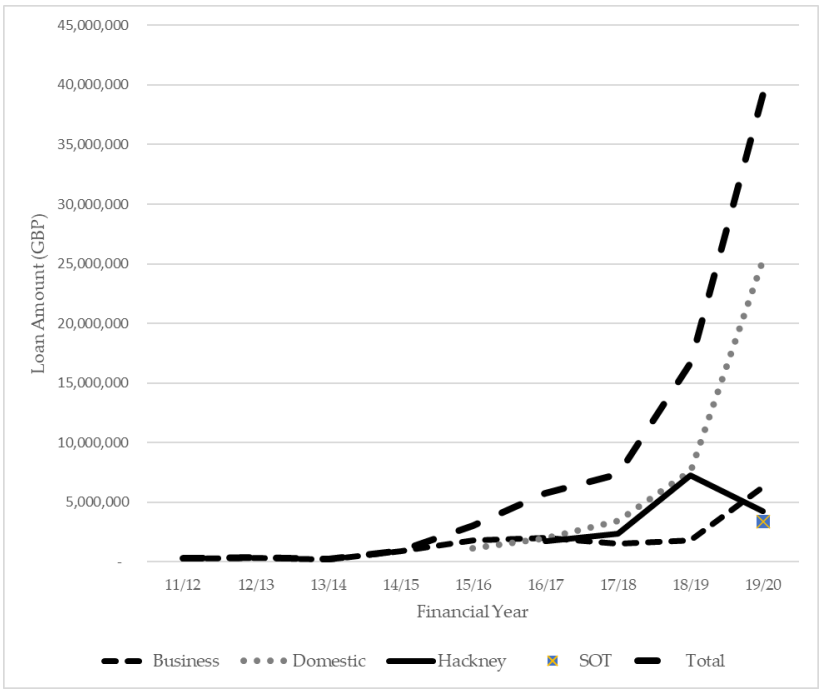


Figure 8. Scotland Low Carbon Transport Loan statistics classified by use: business, domestic, hackney and switched on taxis (SOT); SOT was launched in May 2019 (source: EST [52], as of 8 April 2020).

To encourage EV take-up, in addition to loan schemes at the national level for EV purchase and support for domestic charging points, Dundee has been offering free parking and

charging for 100% EVs and charging tariffs are only now being introduced. Tariffs currently depend on the type/speed of chargepoints. "Slow" chargepoints are typically charged at 10–20 p/kWh, "fast" chargepoints cost 20–30 p/kWh with connection fees of around GBP 0.50, while "rapid" chargepoints charge users 30 p/kWh and above with connection fees of around GBP 1–2. Dundee also owns its fleet of EVs with dedicated council charge points. Membership of ChargePlace Scotland confers benefits of broader access to charge points across Scotland. Recorded charging sessions have been growing steadily according to figures published in the Drive Dundee Electric (https://www.drivedundeeelectric.co.uk/) campaign. However, while these measures will appear to align with SDGs 7, 11 and 13 directly or indirectly, the equitability of the funding arrangements and hence the possibility of achieving "systemic impact" can be questioned since the setup appears to perpetuate a two-tier system arising from the "destination" charging nature of the infrastructure.

The Electric Vehicle Homecharge Scheme (EVHS) offers a grant contribution towards the installation of domestic chargepoints and the Low Carbon Transport Loan Fund offers a six-year, interest-free loan up to GBP 35,000 towards the purchase of a new EV [27]. However, Dundee's average minimum wage is an indication that subscription to these schemes may be low. Dundee has 71.5% (Scotland 73.3%) of its population in full-time employment, of which 6.8% (10.7% nationally) earn less than the minimum wage as of Q3, 2019 (Scotland's Official Statistics (SOS) [53]. The statistics also show average gross weekly earnings (all patterns of work) of GBP 495.6 (national GBP 548.4), with males earning GBP 579.1 (national GBP 655.6) and females GBP 428 (national GBP 452.1), meaning a gender pay gap of 10.6%. These figures raise questions about EV affordability by Dundee residents with gender discrepancies that may mean EV infrastructure use may be inequitable contrary to SDGs 5 and 10.

5.2.3. Planning Authority Considerations

As a means of promoting sustainable travel, Dundee's planning approval process now requires that before the commencement of work on a site, details of a charging point for EVs shall be submitted to the Council and subsequently installed and fully operational before the first occupation of the flats and offices. By searching the database of planning approvals from 2013, we identified 20 such applications that included an EV infrastructure installation plan. Of these, three were refused, including plans for a park and ride facility and a proposal for a residential estate. The latter was approved subject to conditions on re-application. Two applications were withdrawn but resubmitted and received approval, and two are currently registered as a pending decision.

We argue that making EV installation compulsory for developers could substantially increase capital cost, which may disadvantage some stakeholders. Incorporating EV installation into planning requirements will ensure that the location of infrastructure corresponds to the "level of urgency" of the need for charging infrastructure and have the potential to achieve "systemic impact" quicker. However, the additional costs to developers, if not subsidised, may represent a barrier. Planning will also consider access to private land and issues regarding TROs and the existence of or proximity to a power supply, which could result in an expensive connection to existing grids or high cost of installing renewable energy infrastructure [27,28].

5.2.4. User Penetration and Cross-County/National Opportunities

The number of battery electric vehicles (BEVs) and other ULEVs licenced in Scotland has grown from 930 and 117 in 2014 Q1 to 7529 and 8581 in 2019 Q4, respectively. The proportion of ULEVs registered for the first time increased from 0.3% in 2014 Q1 to 3.6% in 2019 Q4 [54]. The preliminary figures for Dundee indicate that ownership of EVs is increasing and use of EV infrastructure (measured by frequency of charging sessions) is growing. Dundee's charge points per 100,000 population are the highest in the region. Still, these numbers may be skewed by the number of EV taxis in the published figures (Table 2),

just like the prevalence of EVs in local authorities (Perth and Kinross and Fife) with park and ride facilities supports the popularity of the destination charging approach.

Table 2. Incentives comparison—Dundee and neighbouring local authorities.

Incentive	Dundee City	Angus	Perth and Kinross	Clackmannanshire	Fife
Residential EV charging	Yes	Being considered	Being considered	Planned	No
EV charging at park and rides	No	No	Yes	No	Yes
Discounted parking for EVs	Yes	Yes	Being considered	No	No
EVs allowed in bus lanes	No	No	No	No	No
EV demos or experience centre	No	Being considered	No	No	No
Low Emission Zone (LEZ) or Policies/Clean Air Zone (CAZ)/Air Quality Management Area (AQMA)	Planned (LEZ)	No	Being considered (CAZ)	No	Yes (AQMA)
Number of charge points	111	59	101	19	98
Number of plug-in vehicles	397	276	457	82	736
Charging devices per 100K population *	61	47	52	33	21

Other
Dundee: GBP 11 reduction in testing fees for electric taxis.
Angus: Angus Council offer free parking to EV users for charging times only.
Perth and Kinross: N/A.
Clackmannanshire: N/A.
Fife: Grant funding for home charging and businesses is provided through Transport Scotland and administrated through the Energy Saving Trust. Fife Council promotes the national ECOStars scheme for business and taxi fleet operators to provide information and support on fleet operating, including advice on EVs. Through ECOStars, Fife Council has run events with the local taxi operators to encourage take-up of the taxi operator grants.

Source: Go Ultra Low (accessed: 19 May 2020), * Department for Transport (DfT), October 2019.

However, with an ambitious 10-year target of EVs representing 20% of all vehicles in the city, there is still a long way to go, with only about 3% of residents driving electric vehicles and a lack of access to home charging for 51% of residents due to the high number of tenement buildings [55].

Table 2 is evidence for joined-up thinking in EV infrastructure development, where ChargePlace Scotland members may give access to various charge points for journeys away from home. This is aligned with SDG 17 (partnership for the goals) and indicates a useful way of addressing "policy gaps" and promoting "systemic impact" across local authorities. However, a differential incentive of the reduction of EV testing fees for Dundee means a cost saving for users that can afford EVs. This could create inequalities for regional registration and use of EVs. We note that broader incentive schemes to discourage unsustainable fossil fuel use will need to consider these differences across local authorities.

5.2.5. Acceptability Relative to Alternative or Complementary Low Carbon Schemes

The acclaim of the EV charging scheme possibly overshadows and gives less visibility to other approaches that could complement or provide arguably better alternative low-carbon outcomes. Dundee has been accused of "greenwashing" its future transport plans by prioritising unaffordable electric cars over public transport and active travel such as cycling [21]. The city's other schemes for promoting sustainable transport include a radio and social media campaign—Get on the Go—for promoting alternative sustainable travel modes including car-sharing; subsidised public transport for kids during school holidays to reduce car use; proposed creation of a low emission zone in 2020; and creation of the Waterfront Active Travel Hub featuring a café and bike repair/rental shop. As well

as promoting swimming, the DCC also encourages pupils to cycle/walk to school by providing a safe environment and making improvements to cycle paths within the city. Perhaps these schemes should attract more attention and funding, resulting in more low-carbon benefits. They could also, in combination with the Drive Dundee Electric campaign, encourage and support more EV uptake. Given that most of the reductions in emissions experienced during the period 2008–2015 have arisen from the domestic and industrial/commercial sectors, pursuing reduction through multiple avenues will allow for addressing "policy gaps" and the attainment of "systemic impact". It will also target different interventions based on the "level of urgency" for each sector.

6. Discussion, Recommendation and Conclusions

In this review, we have considered the challenge of determining the interventions that should be selected and prioritised to achieve the SDGs. This challenge manifests in the extant literature as uncertainty about the mechanisms of national SDG implementation [2–4], and the translation of the SDGs into identifiable interventions contextually relevant to the needs of an adopting country, cascading down to national priorities and the developmental needs of local authorities, cities and communities [7,8]. The challenge could also be methodological, concerning identification, measurement and replicability of targets/indicators [7], as well as difficulties in matching interventions to the SDGs or for comparison of SDG interventions between countries [9–12]. From a carbon emission perspective, investments in green infrastructure may not necessarily allow for optimisation of asset pricing and performance [56], given that non-linear dynamics [17] and power relations [19] come into play. Moreover, Dincer [57] argues that environmental problems need the establishment of potential long-term actions for sustainable development. However, these are not always amenable to predicting future uptake and benefits. As such, the SDGs have emerged as a useful basis for successfully setting the agenda of green infrastructure projects and for navigating the distracting factors.

The MCA [18] provides a structured approach for examining interventions linked to the SDGs by examining their "level of urgency", "systemic impact" and "policy gaps". Employing these criteria holistically rather than the specific mechanics for measuring and weighting granular indicators and targets, we have undertaken a positive review of the context within which Dundee has adopted an EV strategy. We have made value arguments to analyse the intervention at a high level, where the actions specified by the intervention by Dundee were linked to the SDGs. The interventions associated with the Dundee EV charging infrastructure strategy have been potentially designed to benefit Dundee residents—an approach widely acclaimed to be successful. Dundee's emergence as a leading EV infrastructural ecosystem results from a combination of unique contextual factors, including leadership committed to responding to climate change—who have declared a climate emergency and have specified explicit climate actions. These factors have favoured a "destination" hub charging approach. Other factors include the existence of allied industries and historical adaptability to transitioning the city's economy. A greener Dundee city is emerging with prominent positive spinoffs for Scotland.

However, mapping the strategy against SDGs 5 (gender equality) and 10 (reducing inequality) raises doubts about equitability and affordability for the city's residents. Presently, the location of infrastructure appears to be outside the reach of domestic users and the affordability of EVs is an issue. Furthermore, the question arises as to whether the EV strategy is the most viable way to achieve low-carbon transport. Misalignment between green interventions and some SDGs could arise from the way policy frameworks are designed in the UK as devolved governments prioritise areas of development based on their perceived needs. Such misalignment also applies to interventions being pursued at local and community levels. Invariably, inequalities are created across local authorities, which while working within the national outcomes of the NPF [25], must implement and optimise plans that are relevant to their context. In this regard, the action plans of Dundee, reviewed here, align directly only with some SDGs. Pursuing a green development plan

suited to the prevailing circumstances of local authorities and cities is leeway to better align interventions with the SDGs.

This paper has reviewed Dundee City Council's EV intervention, raising the questions of equitability and viability by examining social factors in combination with the traditional incentive-based rational economic choice factors like affordability. Geels et al. [17] opine that such a multi-level perspective—i.e., examining social, political, cultural and technical aspects—is crucial for effectively assessing low-carbon transitions. Dundee's EV intervention, as has been acclaimed, is a thriving clean energy intervention which is acceptable to the city's young working-class population that is sensitive to the environmental implications of transportation. The scheme's popularity appears to relate closely to the green nudges ideology of employing behavioural policy tools to encourage consumers to act in an environmentally benign way [58], although the efficacy of the approach in isolation is questionable. Thus, some have argued that active travel projects in the city should be prioritised over the EV scheme. Apparently, Dundee's successful bids for infrastructure development funding and the high visibility of this project augurs well for scalability and adoption by smaller, similar or bigger cities—especially in Scotland. However, the sustainability of Dundee's EV scheme is dependent on the success of various grant schemes, Dundee's physical context, affordability by residents (also linked to deprivation issues and social factors), acceptability and focus of the intervention—given different emitting sectors such as domestic, industrial/commercial and transport.

It is conclusive that DCC's EV project was planned and executed in alignment with many of the SDGs, but this alignment can be upscaled. To better align projects to the SDGs, projects must be equitable and viable from a localisation perspective, where the specific characteristics of the local authority are taken into consideration. We recommend that the immediate needs of the city-dwellers should be considered first to ensure effective and equitable mapping of green policy interventions with the SDGs. Furthermore, such responses should determine the perception and weights/ranking of the SDGs amongst a broader spectrum of the society. We further recommend the consideration of prevailing needs in the city which align with SDGs 5 and 10. Access must extend to low-income groups across the city and neighbouring towns to improve the alignment of the EV project in Dundee.

Finally, it will be useful to consider carefully and to understand, perhaps in a future study, how SDGs are being adopted—given more urgent needs competing for resources in Dundee. Such a study will contribute to the discourse, in the broader context, of how cities and local authorities can justify investment in green infrastructure given competing local needs for limited funds and differential residents' situations and aspirations.

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